

We Claim:

1. An anodizing system for forming an anodized coating on at least a portion of a substrate thereby creating an anodized substrate, said anodizing system including:

5 (a) a bath into which the substrate is placed to facilitate the formation of the anodized coating on at least a portion of the substrate thereby creating the anodized substrate; and

(b) a coating thickness monitor for measuring the thickness of at least a portion of the anodized coating on the substrate formed in said bath, said coating thickness monitor including:

10 (i) at least one radiation source directed at at least a portion of the anodized substrate,

(ii) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed at the anodized substrate from said radiation source, and

15 (iii) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate.

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2. The anodizing system of Claim 1 further including at least one controller in communication with said coating thickness monitor.

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3. The anodizing system according to Claim 2 wherein said at least one controller regulates a relative movement of said probe and the anodized substrate.

4. The anodizing system according to Claim 2 wherein said at least one controller regulates at least one process parameter of said bath.

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5. The anodizing system according to Claim 4 wherein said at least one process parameter includes at least one of bath chemistry, bath temperature, anodizing voltage, anodizing current and anodizing time.

5 6. The anodizing system according to Claim 2 wherein said at least one controller regulates a process endpoint.

7. A coating thickness monitor for measuring the thickness of at least a portion of an anodized coating on at least a portion of a substrate formed in an anodizing system having a bath into which the substrate is placed to facilitate the formation of the anodized coating on the substrate thereby creating the anodized substrate, said coating thickness monitor including:

(a) at least one radiation source directed at at least a portion of the anodized substrate;

15 (b) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source;

20 (c) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate; and

(d) a guide system capable of transmitting the captured radiation from said at least one probe to said at least one detector.

25 8. The coating thickness monitor according to Claim 7 wherein said guide system is an optical guide.

9. The coating thickness monitor according to Claim 8 wherein said optical guide is an optical fiber.

10. The coating thickness monitor according to Claim 9 wherein said optical fiber is a plurality of optical fibers.

11. The coating thickness monitor according to Claim 8 further including  
5 an additional guide system capable of transmitting at least a portion of the radiation from said at least one radiation source to direct the at least a portion of the radiation at at least a portion of the anodized substrate.

12. The coating thickness monitor according to Claim 11 wherein said  
10 additional guide system is an additional optical guide.

13. The coating thickness monitor according to Claim 12 wherein said additional optical guide is an optical fiber.

14. The coating thickness monitor according to Claim 13 wherein said  
15 additional optical fiber is a plurality of optical fibers.

15. The coating thickness monitor according to Claim 11 further including a supplementary guide system capable of at least one of: (1) transmitting additional  
20 captured radiation from said at least one probe to said at least one detector; (2) transmitting at least a portion of the radiation from at least one additional radiation source to direct at least a portion of the additional radiation at at least a portion of the anodized substrate; and (3) transmitting at least a portion of the additional radiation from at least one additional radiation source to direct the at least a portion of the  
25 additional radiation at at least a portion of the anodized substrate and transmitting the additional captured radiation from said at least one probe to said at least one detector, the additional captured radiation being at least a portion of the additional radiation directed at the anodized substrate from said at least one additional radiation source.

16. The coating thickness monitor according to Claim 14 wherein said  
30 supplementary guide is an additional optical guide.

17. The coating thickness monitor according to Claim 16 wherein the said optical guide is an optical fiber.

5 18. The coating thickness monitor according to Claim 16 wherein the said optical fiber is a plurality of optical fibers.

19. The coating thickness monitor according to Claim 15 wherein said guide system and said supplementary guide system are selected to be capable of  
10 transmitting a broad spectral range of captured radiation from said at least one probe to said at least one detector.

20. The coating thickness monitor according to Claim 7 wherein said at least one radiation source is polychromatic.

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21. The coating thickness monitor according to Claim 20 wherein the polychromatic radiation includes at least one of ultraviolet radiation, visible radiation, and infrared radiation.

20 22. The coating thickness monitor according to Claim 7 wherein said at least one source radiation is monochromatic.

23. The coating thickness monitor according to Claim 7 further including an additional radiation source.

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24. The coating thickness monitor according to Claim 23 wherein said additional radiation is polychromatic.

25. The coating thickness monitor according to Claim 23 wherein said  
30 additional polychromatic radiation is at least one of ultraviolet radiation, visible radiation, and infrared radiation.

26. The coating thickness monitor according to Claim 23 wherein said additional radiation is monochromatic.

5           27. The coating thickness monitor according to Claim 23 wherein a spectral range of said at least one radiation source and a spectral range of said additional radiation source partially overlap.

28. The coating thickness monitor according to Claim 27 wherein said  
10 partial overlap increases at least one of a signal to noise ratio for the captured radiation and a total spectral range of captures radiation.

29. The coating thickness monitor according to Claim 23 wherein one of  
said at least one radiation source and said additional radiation source is visible  
15 radiation and the other of said at least radiation source and said additional radiation source is infrared radiation.

30. The coating thickness monitor according to Claim 7 said at least one probe further includes a collimator.

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31. The coating thickness monitor according to Claim 30 wherein said collimator facilities a depth of field of a sufficient value to measure the anodized coating thickness.

25           32. The coating thickness monitor according to Claim 7 wherein said at least one probe is external to said bath.

33. The coating thickness monitor according to Claim 7 wherein the at least one probe is within said bath.

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34. The coating thickness monitor according to Claim 7 wherein said at least one detector includes an interferometer.

35. The coating thickness monitor according to Claim 7 wherein said processing of the captured radiation to determine the coating thickness by said coating thickness monitor includes at least one of using a color, using an interference pattern, using an amount of absorbed radiation, using an intensities ratio of a minimum reflected radiation wavelength and a maximum reflected radiation wavelength, and using a Fast Fourier Transformation (FFT) of the captured radiation.

36. The coating thickness monitor according to Claim 7 wherein said processing of the captured radiation to determine the coating thickness by said coating thickness monitor includes using a Fast Fourier Transformation (FFT) of the captured radiation.

37. An anodizing system for forming an anodized coating on at least a portion of a substrate thereby creating an anodized substrate, said anodizing system including:

(a) a bath into which the substrate is placed to facilitate the formation of the anodized coating on at least a portion of the substrate thereby creating the anodized substrate;

(b) a coating thickness monitor for measuring the thickness of at least a portion of the anodized coating on the substrate formed in said bath, said coating thickness monitor including:

(i) at least one radiation source directed at at least a portion of the anodized substrate;

(ii) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source;

- (iii) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate; and
- 5 (iv) at least one guide system capable of transmitting the captured radiation from said at least one probe to said at least one detector; and
- (c) at least one controller in communication with said coating thickness monitor and said bath.

10 38. The anodizing system according to Claim 37 wherein said at least one controller regulates a relative movement of said probe and the anodized substrate.

15 39. The anodizing system according to Claim 37 wherein said at least one controller regulates at least one process parameter of said bath.

40. The anodizing system according to Claim 38 wherein said at least one process parameter includes at least one of bath chemistry, bath temperature, anodizing voltage, anodizing current and anodizing time.

20 41. The anodizing system according to Claim 37 wherein said at least one controller regulates a process endpoint.

25 42. The coating thickness monitor according to Claim 37 wherein said guide system is an optical guide.

43. The coating thickness monitor according to Claim 42 wherein said optical guide is an optical fiber.

30 44. The coating thickness monitor according to Claim 43 wherein said optical fiber is a plurality of optical fibers.

45. The coating thickness monitor according to Claim 42 further including an additional guide system capable of transmitting at least a portion of the radiation from said at least one radiation source to direct the at least a portion of the radiation at  
5 at least a portion of the anodized substrate.

46. The coating thickness monitor according to Claim 45 wherein said additional guide system is an additional optical guide.

10 47. The coating thickness monitor according to Claim 46 wherein said additional optical guide is an optical fiber.

48. The coating thickness monitor according to Claim 47 wherein said additional optical fiber is a plurality of optical fibers.  
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49. The coating thickness monitor according to Claim 45 further including a supplementary guide system capable of at least one of: (1) transmitting additional captured radiation from said at least one probe to said at least one detector; (2) transmitting at least a portion of the radiation from at least one additional radiation  
20 source to direct at least a portion of the additional radiation at at least a portion of the anodized substrate; and (3) transmitting at least a portion of the additional radiation from at least one additional radiation source to direct the at least a portion of the additional radiation at at least a portion of the anodized substrate and transmitting the additional captured radiation from said at least one probe to said at least one detector,  
25 the additional captured radiation being at least a portion of the additional radiation directed at the anodized substrate from said at least one additional radiation source.

50. The coating thickness monitor according to Claim 48 wherein said supplementary guide is an additional optical guide.  
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51. The coating thickness monitor according to Claim 50 wherein the said optical guide is an optical fiber.

52. The coating thickness monitor according to Claim 50 wherein the said  
5 optical fiber is a plurality of optical fibers.

53. The coating thickness monitor according to Claim 49 wherein said guide system and said supplementary guide system are selected to be capable of transmitting a broad spectral range of captured radiation from said at least one probe  
10 to said at least one detector.

54. The coating thickness monitor according to Claim 37 wherein said at least one radiation source is polychromatic.

15 55. The coating thickness monitor according to Claim 54 wherein the polychromatic radiation includes at least one of ultraviolet radiation, visible radiation, and infrared radiation.

56. The coating thickness monitor according to Claim 37 wherein said at  
20 least one source radiation is monochromatic.

57. The coating thickness monitor according to Claim 37 further including an additional radiation source.

25 58. The coating thickness monitor according to Claim 57 wherein said additional radiation is polychromatic.

59. The coating thickness monitor according to Claim 57 wherein said additional polychromatic radiation is at least one of ultraviolet radiation, visible  
30 radiation, and infrared radiation.

60. The coating thickness monitor according to Claim 57 wherein said additional radiation is monochromatic.

61. The coating thickness monitor according to Claim 57 wherein a  
5 spectral range of said at least one radiation source and a spectral range of said additional radiation source partially overlap.

62. The coating thickness monitor according to Claim 61 wherein said  
10 partial overlap increases at least one of a signal to noise ratio for the captured radiation and a total spectral range of captures radiation.

63. The coating thickness monitor according to Claim 57 wherein one of  
said at least one radiation source and said additional radiation source is visible  
radiation and the other of said at least radiation source and said additional radiation  
15 source is infrared radiation.

64. The coating thickness monitor according to Claim 37 said at least one  
probe further includes a collimator.

20 65. The coating thickness monitor according to Claim 64 wherein said collimator facilities a depth of field of a sufficient value to measure the anodized coating thickness.

66. The coating thickness monitor according to Claim 37 wherein said at  
25 least one probe is external to said bath.

67. The coating thickness monitor according to Claim 37 wherein the at  
least one probe is within said bath.

30 68. The coating thickness monitor according to Claim 37 wherein said at least one detector includes an interferometer.

69. The coating thickness monitor according to Claim 37 wherein said processing of the captured radiation to determine the coating thickness by said coating thickness monitor includes at least one of using a color, using an interference pattern, using an amount of absorbed radiation, using an intensities ratio of a minimum reflected radiation wavelength and a maximum reflected radiation wavelength, and using a Fast Fourier Transformation (FFT) of the captured radiation.

70. The coating thickness monitor according to Claim 37 wherein said processing of the captured radiation to determine the coating thickness by said coating thickness monitor includes using a Fast Fourier Transformation (FFT) of the captured radiation.

71. A method for forming a anodized coating on at least a portion of a substrate thereby creating an anodized substrate, said method including:

- (a) using an anodizing system having a bath;
- (b) placing the substrate into the bath to facilitate the formation of the anodized coating on at least a portion of the substrate thereby creating the anodized substrate; and
- (c) measuring the anodized coating with a coating thickness monitor to determine the thickness of at least a portion of the anodized coating on the substrate formed in said bath, said measuring including:
  - (i) directing at least one radiation source at at least a portion of the anodized substrate;
  - (ii) capturing with at least one probe at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source; and
  - (iii) transmitting to at least one detector from said at least one probe said captured radiation, said at least one detector

capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate.

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- 10                   (a)     providing coating thickness monitor;
- (b)     directing at least one radiation source at at least a portion of the anodized substrate;
- (c)     capturing using at least one probe at least a portion of the radiation reflected and refracted by the anodized coating on the anodized
- 15                   substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source;
- (d)     transmitting the captured radiation using a guide system from said at least one probe to said at least one detector; and
- (e)     processing the captured radiation to allow a determination of at
- 20                   least the thickness of the anodized coating on the substrate.

73.     A method for forming a anodized coating using an anodizing system on at least a portion of a substrate thereby creating an anodized substrate, said method including:
- 25                   (a)     providing anodizing system;
- (b)     placing the substrate into a bath to facilitate the formation of the anodized coating on at least a portion of on the substrate thereby creating the anodized substrate;
- (c)     measuring using a coating thickness monitor a thickness of at
- 30                   least a portion of the anodized coating on the substrate formed in said bath, said measuring using the coating thickness monitor including:

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- (i) directing at least one radiation source at at least a portion of the anodized substrate;
- (ii) capturing using at least one probe at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source;
- 10 (iii) transmitting using at least one guide system the captured radiation from said at least one probe to at least one detector; and
- (iv) processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate; and
- 15 (d) communicating the determined coating thickness with at least one controller.

74. A substrate including an anodized coating, said coating having a thickness quality of about 1.3 times better than a coating thickness quality of an anodized substrate made without a coating thickness monitor communicating with a controller, said coating thickness monitor including:

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- (a) at least one radiation source directed at at least a portion of the anodized substrate;
- (b) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source; and
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- (c) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate.
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75. The substrate of claim 74 further including an additional coating on said anodized coating.

76. A substrate including an anodized coating, said coating having a thickness quality of at least about 1.3 times better and a thickness consistency of about 1.6 time thereby having a quality x consistency product at least about 2 times better than a coating thickness quality x consistency product of an anodized substrate made without a coating thickness monitor communicating with a controller, said coating thickness monitor including:

(a) at least one radiation source directed at at least a portion of the anodized substrate;

(b) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source; and

(c) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate.

77. A substrate including an anodized coating and an additional coating on said anodized coating, said anodized coating having a thickness quality of at least about 1.3 times better and a thickness consistency of about 1.6 time better thereby having a quality x consistency product at least about 2 time better than a coating thickness quality x consistency product of an anodized substrate made without a coating thickness monitor communicating with a controller, said coating thickness monitor including:

(a) at least one radiation source directed at at least a portion of the anodized substrate;

(b) at least one probe for capturing at least a portion of the radiation reflected and refracted by the anodized coating on the anodized substrate, the captured radiation being at least a portion of the radiation directed the anodized substrate from said radiation source; and

5 (c) at least one detector in communication with said at least one probe, said at least one detector capable of processing the captured radiation to allow a determination of at least the thickness of the anodized coating on the substrate.

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